

Agricultural Research: Changing of the Guard, Guarding the Change

Inaugural AAAS Charles Valentine Riley Memorial Lecture

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Thank you for that kind introduction, and to the Committee for selecting me to deliver this inaugural lecture celebrating C.V. Riley, a preeminent entomologist who worked to benefit agriculture as a scientist with the U.S. Department of Agriculture. I am honored to be in this role this evening.

Mr. Riley, who emigrated to the U.S. in 1860 worked as a farm laborer, writer and artist. He was named in 1868 as Missouri's first State Entomologist and advanced to be Chief of the U.S. Entomological Commission in 1878. His work led to the first successful use biological control, control of scale insects in citrus in California. He had a similar success in reducing insect damage to the French wine industry. Mr. Riley also played a significant role in establishing a National Office of Experiment Stations, the precursor to today's Agricultural Research Service, and other important changes in the USDA. He was a renaissance man in many different ways.

I think it extremely fitting that this inaugural lecture of the series takes place under the auspices of the AAAS, the largest scientific organization in the U.S. and perhaps internationally. The Association is devoted to many different topics and is a model for many other science organizations around the globe. The imprimatur of the AAAS for the Riley Lecture, with the society's historical twin focus on urging support for research and encouraging science-based policy decisions, lends credibility and urgency to the themes I want to address this afternoon – the transformative change which is underway in agricultural science, and how that change can and must inform the discovery and implementation of solutions to the most vexing of human problems.

That we are at a watershed moment in agriculture is likely taken as a given by many in this audience; but perhaps not by those who are less familiar with the critical role that agriculture plays in global issues. We have a disturbing tendency in American

society – indeed, in the developed world – to equate truisms for truth. Consider, for example, what I often refer to as the “arrogance of plenty”: the average Westerner gives little or no thought to whether there will be food tomorrow in the supermarket, that there will be fuel to power our cars and to heat and cool our homes, that there will be fiber for our clothes, paper for our books and printers, and timber to build our houses. It has been decades since these were top-of-mind concerns for most Americans – although we still have a big job to do to make sure that hunger is solved even in the United States.

The plenty that we enjoy, enabled by one of the highest standards of living in the world and subsidized by energy use per capita that far outstrips that of any other nation, has fostered – one might even say fore-ordained – a culture of neglect for agricultural science for more than 50 years. Because we do not feel the hunger that gnaws at nearly a billion of the world’s citizens, and because the few American farmers that feed America and much of the world are often out of sight and mind of urbanites, we have become complacent in the support and advocacy for agricultural science. Perhaps even more concerning is that agriculture has become the whipping boy for those who look at the landscape of our great country.

It was not always thus, of course. With the nation at war with itself, the need to boost the economy to ensure sufficient funds to conduct the war, and the future of the nation anything but certain, President Lincoln turned to investments in science and research to secure the future. During his presidency he created what we today know as the U.S. Department of Agriculture and founded the land-grant universities to teach agriculture and engineering. These investments, coupled with other far-sighted acts of Congress and presidents through the years, created the most productive agricultural system this earth has ever known. These investments continue to pay incredible dividends in production agriculture, rural and urban wealth, food security, and protection and stewardship of our natural resources.

But I am here this afternoon to tell you that we are most assuredly living on the fruits of past investments while our current opportunities and future wealth and health of rural communities could well wither under the summer sun of complacency.

When President Lincoln created what would become USDA, he was fond of referring to it as “the People’s Department” – a fact, not just a jingle - in that more than half of Americans in his day derived their livelihoods proximally from agricultural work: livelihoods came largely from their labors on the farm. This is the philosophy that underpinned research investments in agriculture for the following 75 years; in the years

just prior to World War II, fully 40 percent of the nation's civilian R&D investments went to agriculture.

Fast forward another 75 years. The agency that I am proud to lead, the National Institute of Food and Agriculture, or NIFA, is the federal government's principal funder of agricultural research conducted at our public institutions, just as the NIH is the nation's principal funder and supporter of biomedical research at these same institutions. In the budget proposed for 2011, the entire NIFA budget is just about the size of the requested 2011 increase of the NIH budget – and all we do is feed the world. Something seems wrong with our spending priorities.

With a few bright blips, federal funding for agricultural research has been stagnant or declining for decades. We are incredibly fortunate to have a robust private sector that is committed to support of research in corporate and public laboratories around the world, and from commodity check-off programs that support research in universities and institutes. The beef industry spends about 15% of its check-off programs, or \$6 million on research; the cotton industry spends about \$11 million of their \$80 million check-off receipts on research; the soybean check-off fund spends about 10% of \$74 million collected on research. And so on. More than \$645 million is collected from producers of blueberries, milk, lamb, potatoes, mangoes, eggs, honey, beef, pork, and many other food commodities.

The great majority of check-off funds go not to support research but for support of marketing and other priorities. Much of the research sponsored by the private sector is focused on relatively short-term, high impact outcomes that will support product lines and bring benefit to the bottom line in relatively short order. This seems to me a mistake at a time when funds are badly needed to advance the fundamental understanding of the organisms on which the science of agriculture and sustainability are based.

It falls, then, to federal funding to secure both the future of the long-term research without which we cannot make the discoveries that have given us our productive and rewarding agricultural economy, and the translation of new knowledge to ensure that discoveries successfully enter the marketplace and provide food security for ourselves and our neighbors. All the while creating sustainable wealth for the rural communities that will provide the food, feed, and fiber to provide food and energy security. Yet, the current level of funding to NIFA is far too small to accomplish all that is required of it.

I recognize that this is not a good time to be calling for massive new federal investments in agricultural research; nevertheless, it is what is needed. We need those investments, and I know that this President and this Secretary of Agriculture believe passionately in agricultural research as a wellspring of future prosperity and job creation, in particular in rural America. We must and we will advocate for strong funding – those of you who know me know that there is no more impassioned advocate to the White House and to Congress. Some of you are aware that I left a role as research scientist and Director of the Danforth Plant Science Center in a great hometown city, St. Louis, working with world-class colleagues who every day were making inroads in solving world hunger. I do not intend to preside over a flat budget at NIFA and a research paradigm more fitted for the 19th century than the 21st. But even I know I must temper that advocacy with a healthy dose of reality.

We must help citizens and decision makers value and return to investment in agricultural research. Concurrently we need to realize the promise of agricultural research to solve the most intransigent problems we face: global food security, even in the face of severe disruptions in climate and weather while mitigating the emissions of greenhouse gases from agriculture; rising childhood obesity; energy security; and food safety among them.

We need to do the research we do better. And we need to make sure the results of that research are known by the policymakers and decision leaders who are charged with formulating sound national policy and making budget decisions.

We need transformative change in the funding and translation of agricultural research into outcomes, solving real problems of real people. And we must measure whether or not we have been successful in doing so, and adjusting our course along the way to be more effective.

There is transformative change in science all around us: it remains to us to embrace it, to harness it for agricultural research, and make sure we aren't changing just for the sake of change.

Last year, the National Academies released its analysis of the research that has been conducted in the life sciences during the past several decades and to project how it will be conducted in the decades to come. For those of you who don't know the report, *The New Biology for the 21st Century*, I highly recommend it, as it is a blueprint for revitalizing agriculture research. The report makes a very compelling case that we are at the cusp of a truly transformative epoch in science and science education. It is a time in which we can make incredible gains by breaking down the silos that separate

physics and chemistry and biology and biomedical sciences and earth sciences and the social sciences, and adopt a unified approach to address bold, big questions. In tone and in detail it is a model for how agricultural science can and must be done in the new scientific landscape (and I quote):

“The lessons of history led the Committee . . . [on a New Biology for the 21st Century to recommend] . . . that a New Biology Initiative be put in place and charged with finding solutions to major societal needs: sustainable food production, protection of the environment, renewable energy, and improvement in human health. These challenges represent both the mechanism for accelerating the emergence of a New Biology and its first fruits.”

Among the changes the Committee foresee, and urge, are an erosion of the traditional academic silos that have hamstrung truly synergistic approaches to science in the past in favor of a more system-wide approach to solve the big problems. In place of the ubiquitous single-investigator model, the New Biology anticipates an increasingly team-oriented approach, where researchers from disciplines as diverse as engineering, biochemistry, food processing, crop and animal science, genetics and physics – teams from departments scattered across campuses, between campuses, and between public and private sector institutions – collaborate to solve large-scale scientific problems.

An example of one such big problem: To understand the puzzle about why the nutritional status of some individuals is more healthy than those of other individuals. The answer to the puzzle will likely come by knowing more about the genetics of the individual, the diversity of microbes in our intestinal tract, and how our diet affects the metabolism of the microbes to release nutrients that we absorb. This question links the sciences of human genomics, nutrition, microbial genomics and population biology, plant genetics and biochemistry, and agriculture itself. This knowledge may reduce obesity and improve nutrition while leading seed and food companies, and perhaps plant genetic engineers, to develop crops and foods that will be optimally matched for individual health and well being.

A similar question could be asked about how to reduce the emissions of greenhouse gasses in production of paddy rice. Solving problems such as this will require the intellect of scientists of many disciplines: implementing the outcomes will require still other disciplines.

Clearly, it will not be business as usual at USDA if we adhere to the conviction that we can and must solve grand societal challenges.

The solutions to the societal challenges requires changes of scientists: changes in the breadth of understanding of their world, and beyond the specialties of their science – to include considering how their work impacts agriculture, environment, health, bioenergy, mitigation or adaptation to climate change; and to the social sciences, including economics, rural and urban social issues, law, business management, to name a few. A daunting challenge for an experienced scientist, and likely impossible for the aspiring young scientist.

Under this mandate it will not be business as usual on the nation's college campuses either, where so much of the nation's research that relates to food and agriculture is performed. One of the most disheartening things that I experienced as a graduate student, post-doctoral scientist, and as a career scientist visiting our colleges and universities, is the great divide – financially, academically, managerially – between the programs where the next generation of agricultural science is taught and research is performed. On some campuses the teaching and training of the very same core sciences given in physics, microbiology, biomedical sciences biochemistry, and other programs are different in different colleges. In some cases the traditional College of Agriculture might as well be a continent removed from the College of Life Sciences or the College of Arts and Sciences for all the cross-pollination and research partnering that occurs. This is not fair to the students, to our field, or to the taxpayers who support our educational systems and expect a payoff in the future in terms of knowledge and service.

The traditional notion of academic success, too, must be reexamined in the context of this new landscape. Tenure decisions that reward single-investigator grant winners over equally productive members of interdisciplinary and multi-institution teams can no longer be the gold standard. Faculty and departments that only perform research – and ignore the vital contributions of extension and education, and other types of translational research – will not thrive in an environment that values multidisciplinary and goal oriented research. Universities should begin to see success of faculty and students as team participants, and reward faculty for their interactions rather than for their independence; on the practical outcomes of their work; and on the preparedness of their students for addressing the challenges of society.

A second agent that is forcing change is the emerging crisis in feeding the world's growing population. The FAO warns that the combined effect of population growth, strong income growth, and urbanization will require a doubling of food production by 2050. This doubling will need to occur despite changes in weather patterns, critical

water shortages, increased soil salinity, and the necessity to reduce the energy and environmental footprints of agricultural practices. And this is not just a problem in “those other countries” that we often talk about: American farmers and foresters already are seeing downward pressure on some production systems, and many areas of the U.S. are as vulnerable to climate disruption as anywhere on earth. Thus far, we have maintained yields of our crops and food animals – but the pressure is increasing.

And because agriculture contributes significantly to greenhouse gas emissions we must reduce emissions from our agriculture, and encourage others to do the same.

Given the enormity of this crisis, we simply cannot afford to ignore any of the tools at our disposal to create the crops and livestock and production practices that will feed our future. We have made huge strides in crop and animal productivity in the US through conventional breeding, and we have robust and powerful breeding programs at USDA and in industry that we must and will support. However, conventional breeding alone will be insufficient to meet this growing need while meeting other societal goals of energy reduction, environmental protection, and a safe food supply. The long cycles needed to successfully breed traditional crop and livestock lines will always keep us behind the eight ball with a rapidly growing population increasingly partial to animal products for food.

Biotechnology gives us a fighting chance to create a world where world hunger needs are met while preserving or even restoring our natural resource base. It can supplement conventional breeding to provide the necessary rapid responses to emerging plant and animal diseases, to the severe climatic disruptions that are anticipated, and to more productive and sustainable agricultural systems.

Consider the increased pressure from insect pests and pathogens that will attack crops globally, and the anticipated reduced fecundity of food animals, including in the U.S., as growing conditions are increasingly too hot, or too dry, or too wet. Pathogens previously seen only in the tropics will attack US crops and new diseases will come to our farm animals. Biotechnology will give us the capacity to respond to challenges in a timely manner; it can give agriculture the potential to stave off rapid onset of diseases and pests. Many scientists think it better to use genetic solutions, including biotechnology, to address these issues rather than to rely more heavily on chemical solutions.

The last agent of change I want to talk about –there are many more, but I don’t

want to stand between you and our distinguished panel! – is the growing awareness of food and agriculture in the minds of the American people. We are becoming a “foodie nation” in many ways. The desire for more locally produced foods, and for food that is more nutritious is evident in many segments of our society. The need to reduce childhood obesity is on the minds of many, from the White House to the mothers in the inner city and all parts of society between. And there is deep concern about the safety of fresh produce and meats. There is increasing concern about the conditions under which our food is produced and processed, and on the impact agriculture has on the environment. Agriculture hasn’t had this kind of top-of-mind relevance for decades.

Many of the discussions focus on an unfortunately vague term, sustainability. Unfortunate, because discussions around sustainability often become emotionally charged and discussants are left with a sour taste. The word sustainability is vague in meaning because by its very nature the concept has multiple dimensions—economic, environmental, and social. And all of these dimensions must be addressed simultaneously if we are to truly develop sustainable agriculture that will produce more of our fuel as well as our food than it does today, yet leave the environment and the consumer in a better place tomorrow than today.

The change we need to embrace here is a commitment to a common understanding of sustainability and using scientific methods to define its reality. An agricultural system is not sustainable, no matter how lucrative it is or how productive it is, if it permits persistent food deserts to exist; or if the cost to transport or process the food adds more than marginal cost to the produce or substantially increases the total greenhouse gas emissions (farm to fork) than is afforded by other methods. An agricultural system is not sustainable if it destroys the environment in which it is located, or has environmental consequences as dire as the food insecurity it is designed to address. Production practices that do not help create rural wealth and allow farmers to stay on the land are not sustainable. Economic practices that do not preserve clean water, reduce greenhouse gas emissions, and maintain natural biodiversity are not sustainable. Social practices that cede agriculture production only to a few agribusinesses are not sustainable.

These are just a few of the grand challenges and the agents of change that are completely and utterly reshaping agriculture. We – in NIFA, in the ARS, and other parts of the USDA, at the nation’s college and universities, and on our farms and forests – need a new research paradigm matched to those changes.

The most visible sign of the transformative change that we have set in motion is the National Institute of Food and Agriculture that we launched in early October. NIFA includes the competitive grants program, AFRI, and awards the formula or capacity funds that many of your universities apply to great effect. AFRI is the flagship research program for competitive grants in the USDA and most of the growth in research support in coming years will reflect our desire to work at meaningful scale on a discrete set of overarching scientific issues, each of which is selected because it has great potential to improve the lives of our citizens. And like its predecessor agency, CSREES, NIFA will ensure that the research we support finds its way into the hands of farmers and foresters, consumers and others through the unique education and extension system that we help to support. In 2010 we began doing this by requiring meaningful linkages between research and extension and/or education in more of our research portfolio.

While other agencies and research performers struggle to effect the translation of bench science to applied science, USDA has for nearly 100 years had a built-in translation capacity unmatched by any other research entity – the Extension Service. And we fully intend to support and grow that capacity through NIFA competitive grants. More of our awards will have requirements for an education and/or outreach through extension than in the past. Similarly, our land grant colleges and universities will see growing opportunities as the competitive grants programs of NIFA grow. They will be part of the change – seeing greater growth through competition rather than entitlement alone.

And our grants will require creating opportunities to recruit more students to the excitement of research in agriculture. We have established a program for NIFA Pre-doctoral and Post-doctoral Scientists to develop the next generation of scientists – many of whom will be trained in a multidisciplinary manner. The NIFA Scholars program we be formally announced on June 21.

We will look, in new ways, to grow our engagement with colleagues at the 1890's land grant colleges and universities and in the tribal colleges; we must reach into the Hispanic and African American communities for talent for the workforce that will become the future of the USDA.

Researchers who want to work with us should prepare themselves to focus in the areas that represent designated targets for our programs: food production and sustainability; biofuels, climate change, and environment; in food safety and nutrition, and in global food security. There will always be grants for single investigators and small teams of scientists: however, there will be an increasing expectation that cross

disciplinary teams, cross institutional and regional teams, will be established to address the grand challenges that were discussed earlier.

NIFA is still a very small agency – by any measure. We will therefore continue to seek partnerships from other federal agencies, including the National Science Foundation, USAID and the Dept. of State, the Dept. of Energy, The Dept. of Defense, the NIH, and others as opportunities arise and synergies are identified.

We must find ways to reduce the duplication of efforts between USDA-funded research and the research conducted in advanced laboratories in the private sector: we don't have enough money to have this luxury. We will seek to reduce duplication where it exists.

We need to find ways to address more of the research questions that are raised by producers of fresh fruits and vegetables, of those that care for the crop pollinators, those that produce organic meats and vegetables, and those who work on small and local farms that serve rural and urban consumers. We will do so.

We need to find ways to make more locally produced food available to our school children and learn more about how to make these fresh goods more appealing, learning more about how children and young adults make their food choices.

We do not have the luxury of funding the many research interests of the scientific community or the food producers that need our input. We probably cannot continue to support the many research programs as separate but equal independent activities within a federal bureaucracy. NIFA and ARS are small agencies with very limited resources. Our competitive programs at NIFA and the intramural research capabilities at the Agricultural Research Service need to be more effectively aligned and harnessed to focus on common goals, even if there are advantages of approaching them differently.

We're just not going to be able to sustain what I call the peanut butter (or perhaps more appropriately sunbutter!) on crackers approach – we have gotten in the habit of using a small jar of peanut butter to try to cover every conceivable cracker that comes our way. And you know, we were able to do that for a time – but it wasn't the best way to do it, nor did it deliver the best research for the money of the American taxpayer.

Today, in this budget and social climate, we have far too many crackers and too little peanut butter. And when we decide how much peanut butter on a cracker is optimum, feeds the most people the most nutritious meal for the lowest cost, we

always have folks who are second guessing us, insisting that their crackers are better and need more peanut butter, or that their crackers always had peanut butter covering all of the cracker surface a foot deep and that's what they need to go forward, or that it's somehow better to have a micron's worth of peanut butter on a cracker with their name on it than a shared cracker with a healthy amount of it on top.

To be more direct, earmarking of small amounts of funds for specific researchers or universities to address specific local problems, does not serve the larger U.S. research enterprise to solving the challenges that face our great nation or the world. This is particularly true for small research agencies such as NIFA and the ARS.

We have to move away from agricultural research as an entitlement program and toward the management of a coordinated science portfolio aimed specifically at target problems. While agriculture per se is place based, the solutions to agricultural problems are based in knowledge that is not place based. .

At the same time, I am deeply cognizant of the awesome responsibility USDA has to ensure the capacity of our colleges and universities to continue to do meaningful and productive research – with state budgets in freefall, now is not the time to pull back our support.

And I am committed to restoring USDA's historical role in building research and production capacity in the developing world – we won't be able to meet the food needs of the future with American produce alone, and the enormity of the need will ensure that American farmers will always have ready markets for their crops and livestock. More countries around the world must be empowered, through knowledge and through enterprise, to be their own producers rather than relying on our surpluses.

C.V. Riley lived and worked through one of the last great transformations in agriculture – the middle and late 1800s.

Yet by all accounts this vibrant and exciting era of agricultural and entomological discovery did not turn Riley into a narrowly focused specialist bent on pursuing a single strand of this emerging scientific landscape. Rather, he is remembered today as a truly a "whole-picture" person - an artist, a poet, a writer, a journalist, a linguist, a naturalist, and a philosopher as well as a scientist.

We would do well to honor his memory this afternoon by finding the common ground we need to make sure our epoch of transformative change will be remembered a hundred years from now for its expansiveness, its vision, its willingness to take risks, and its commitment to solving the biggest problems we can.

I am excited, and humbled, by the magnitude, the audacity, of this challenge – and I will be grateful for your wisdom and guidance as we meet it together as guardians of the change that will re-make the field of agricultural research.